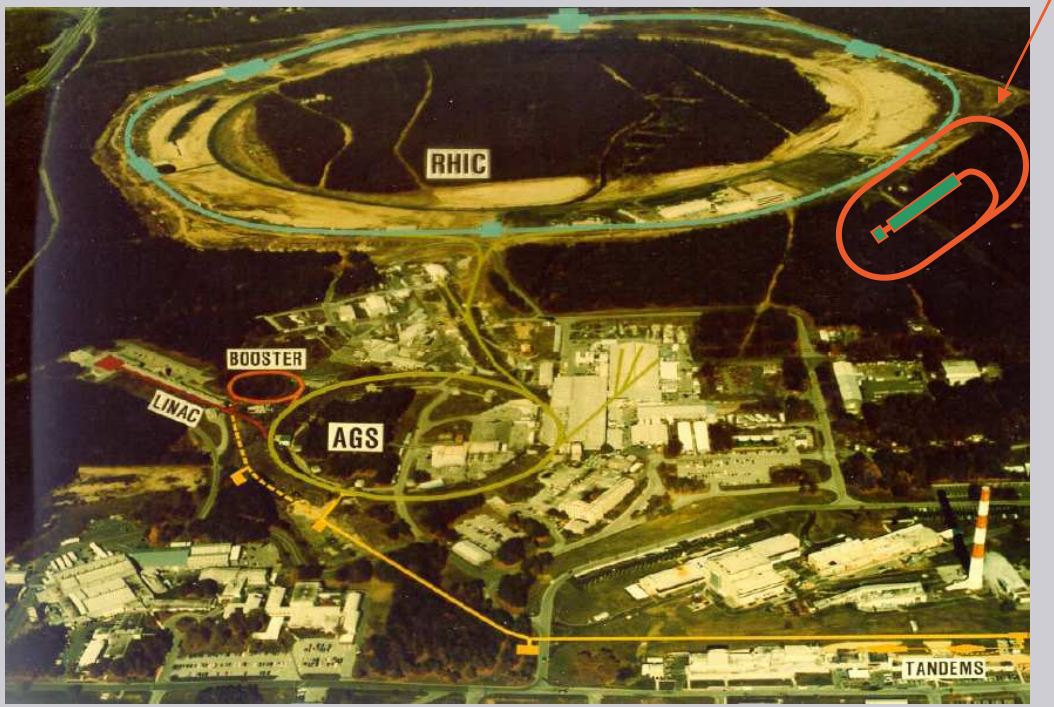
eRHIC – Future Electron-Ion Collider at BNL

V.Ptitsyn

C-AD, BNL

What is eRHIC?

Relativistic Heavy Ion Collider + Electron accelerator



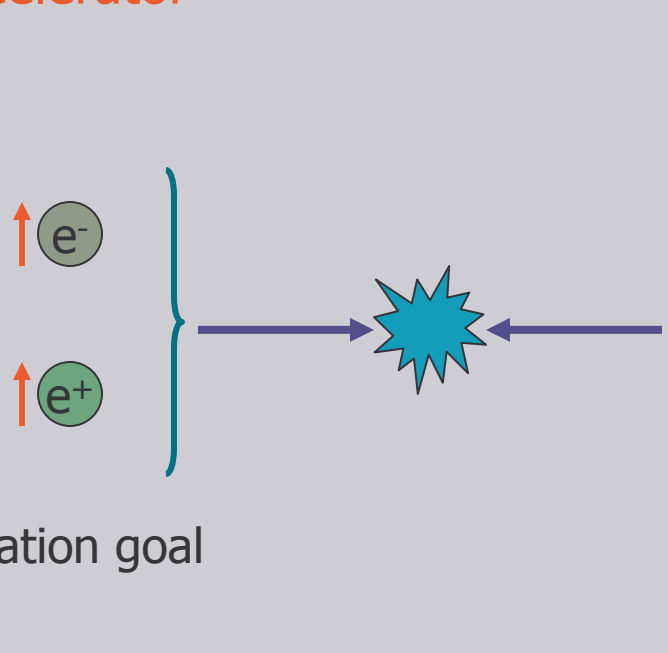
A high energy, high intensity polarized electron/positron beam facility could be built at BNL to provide collisions with the existing heavy ion and polarized proton beam.

To probe **fundamental aspects of QCD**

eRHIC Scope

Electron accelerator

RHIC



Polarized protons
50-250 Gev

Polarized leptons
5-10 Gev

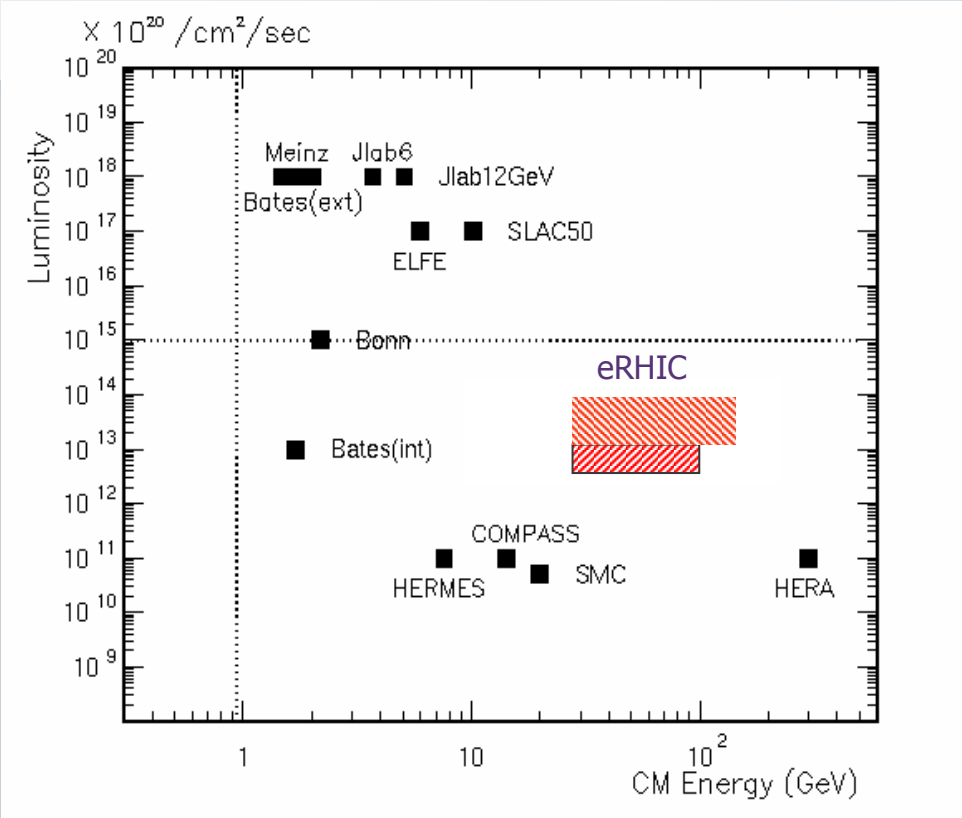
Heavy ions (Au)
100 Gev/u

70% beam polarization goal

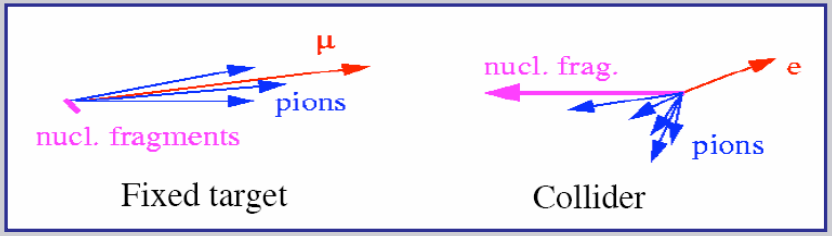
Polarized light ions (He^3)
167 Gev/u

Center mass energy range: 30-100 Gev

Advantages of collider



- Polarized DIS in past only in fixed target mode
- With collider:
  - Higher Center of Mass energies reachable.
  - Better angular resolution between beam and target fragments

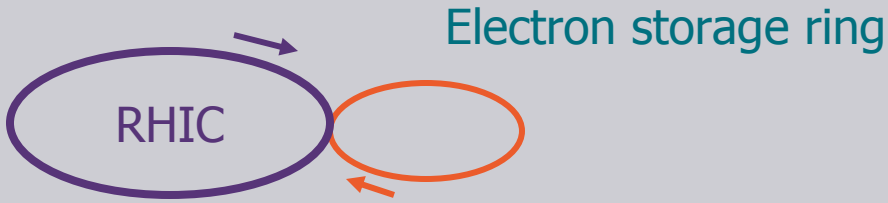


Goal luminosities:

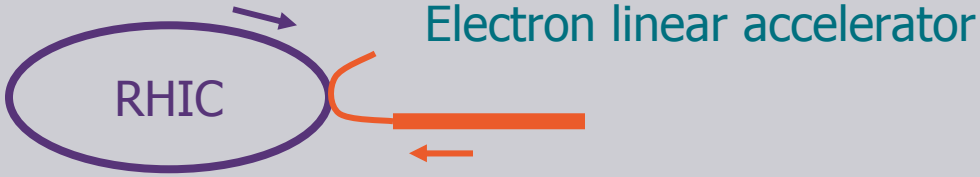
- in 10^{32} - 10^{34} $cm^{-2}s^{-1}$ range for e-p collisions
- in 10^{30} - 10^{32} $cm^{-2}s^{-1}$ range for e-Au collisions

How eRHIC can be realized?

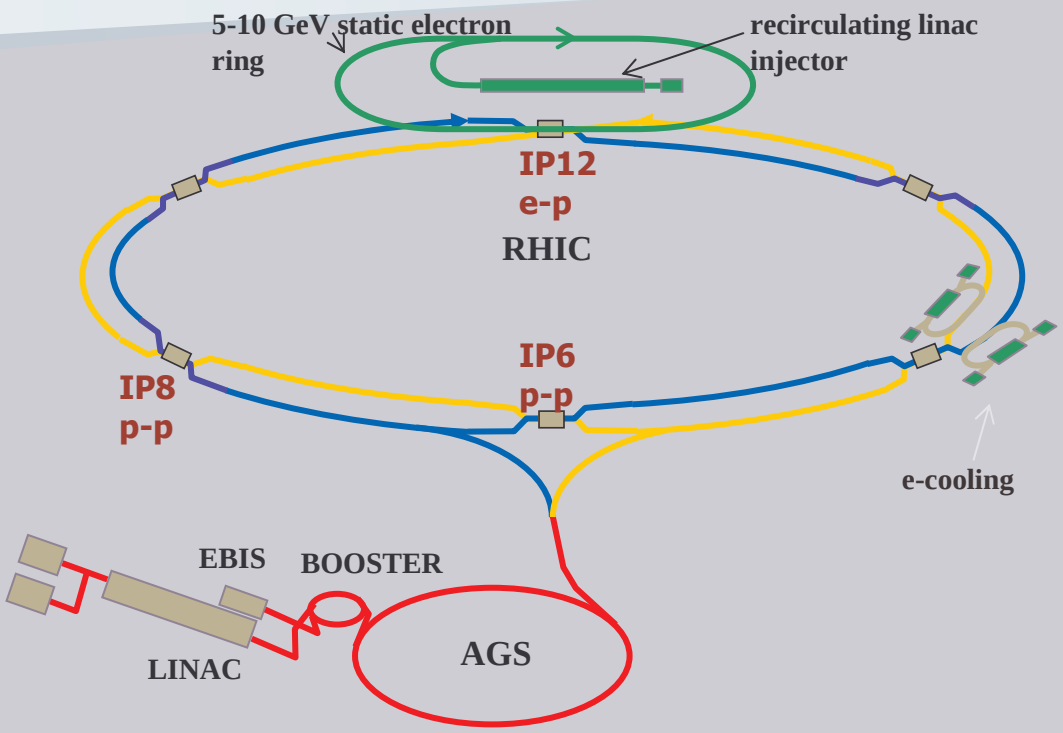
- Two main design options:
  - Ring-ring:



  - Linac-ring:



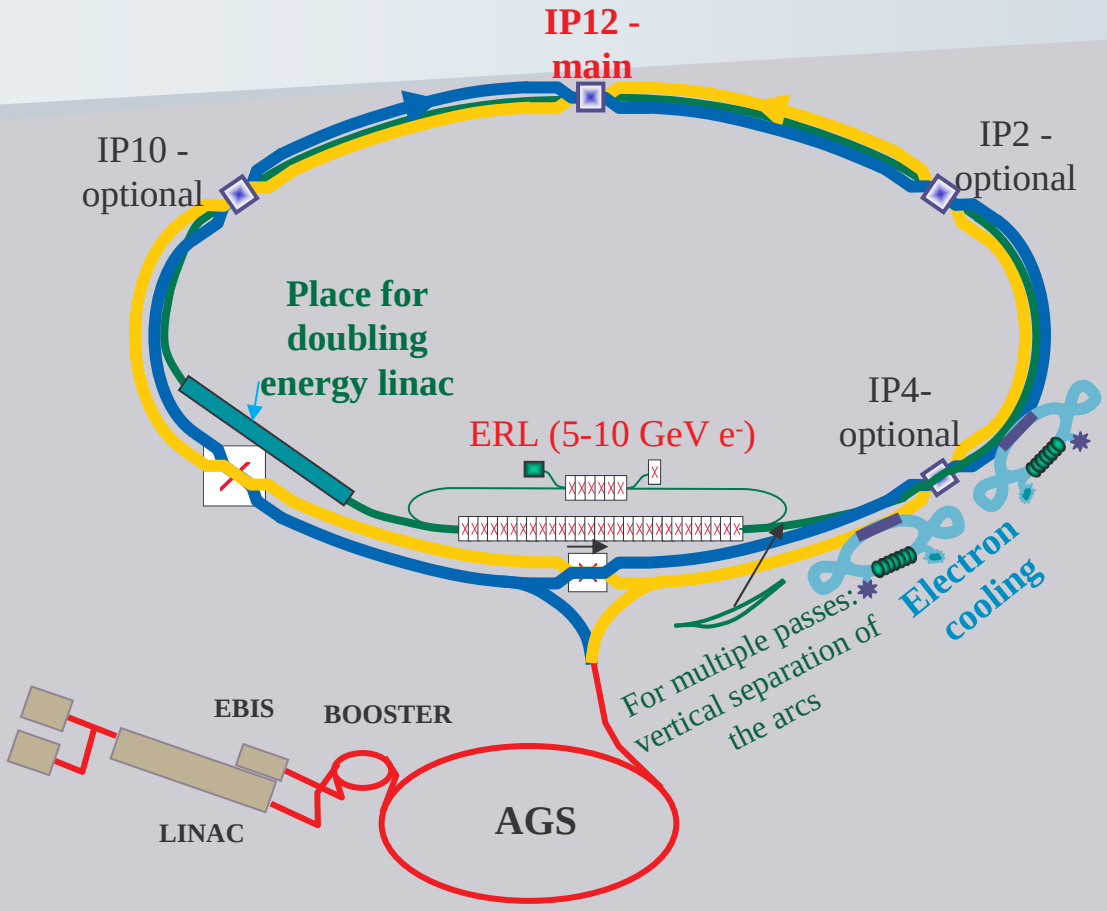
Ring-ring design option



The e-ring design development led by MIT-Bates.
Technology similar to used at B-factories.

- The electron ring of 1/3 of the RHIC ion ring circumference
- Full energy injection using polarized electron source and 10 GeV energy linac.
- e-ion collisions in one interaction point.
  (Parallel mode : Ion-ion collisions in IP6 and IP8 at the same time are possible.)
- Longitudinal polarization produced by local spin rotators in interaction regions.
- Present design luminosities (for high energy setup):
  - e-p: $4.4\ 10^{32}\ cm^{-2}s^{-1}$
  - e-Au: $4.4\ 10^{30}\ cm^{-2}s^{-1}$
  - e-He^3: $3.1\ 10^{32}\ cm^{-2}s^{-1}$

Linac-ring design



Design being developed at BNL

- Electron beam is transported to collision point(s) directly from **superconducting energy recovery linac (ERL).**
- No beam-beam limitation for electron beam (the beam is used once!).
- No prohibited energy areas for the polarization.
- No spin rotators needed.
- e-p luminosity $>10^{33}$ cm^{-2}s^{-1} possible
- But no straightforward way to get polarized positrons

Luminosity for different options

- **Linac-Ring:**

$$L = \gamma_i \, f_c \, N_i \, \frac{\xi_i Z_i}{\beta_i^* \, r_i}$$

No electron beam-beam limit on ion current.

Luminosity is defined by ion beam parameters.

IR design allows for round beams at the collision point.

- **Ring-ring:**

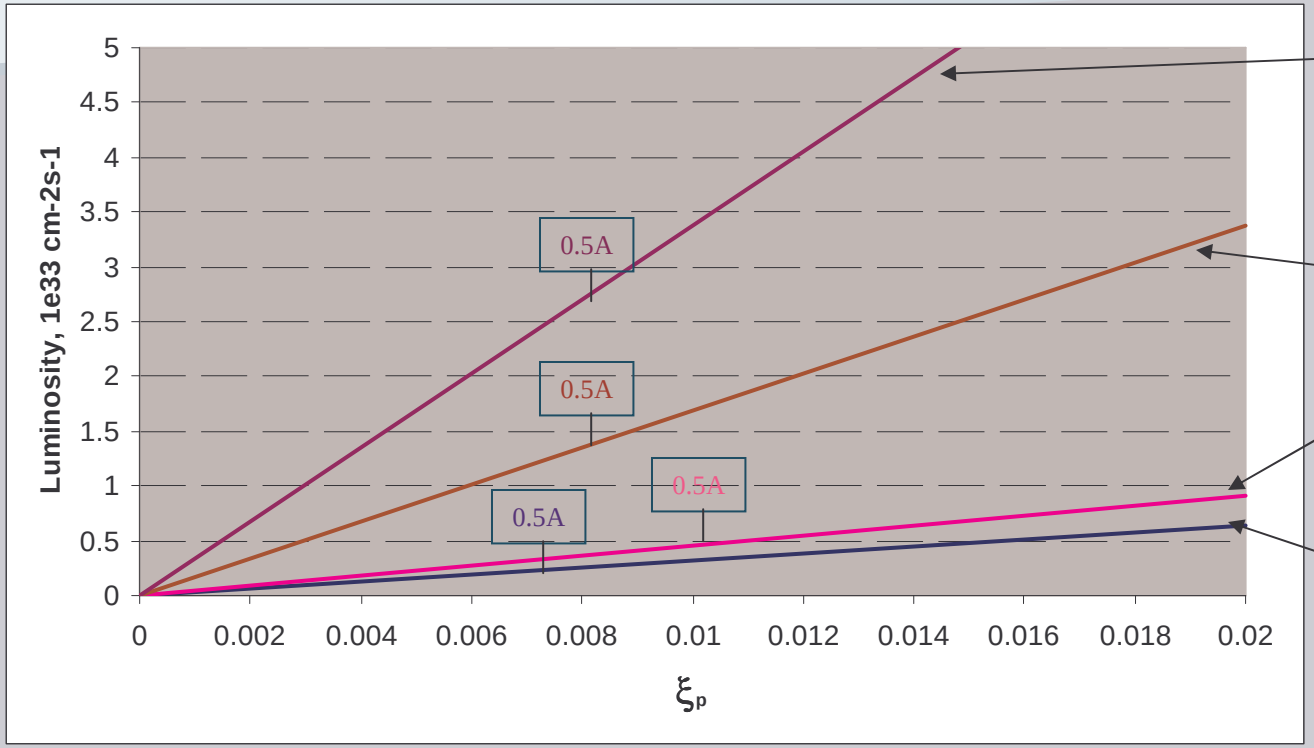
$$L = f_c \, \frac{\pi \gamma_i \gamma_e}{r_i r_e} \xi_{xi} \xi_{ye} \sigma'_{xi} \sigma'_{ye} \, \frac{(1+K)^2}{K}$$

Limitation from IR design (septum magnet aperture) leads to elliptical beam (vertical to horizontal beam size ratio: K=1/2) and the limit on σ'_{xi}

Electron beam-beam limit ($\xi_e < 0.08$) prevents proton intensity more than 1e11 p/bunch

Luminosity versus proton beam-beam parameter

Calculations for 360 bunch mode and 250 Gev(p) x 10 Gev(e) setup



Marks show locations on the luminosity lines where electron current reaches 0.5A, which is presently nominal design current for both options.

In parallel mode (1 e-p + 2 p-p collision points): ξ_p~0.0065;
In dedicated mode (only e-p collision): maximum ξ_p~0.018;

Major R&D issues

- **Ring-ring:**
  - The accommodation of synchrotron radiation power load on vacuum chamber. (To go beyond 5.e32 $cm^{-2}s^{-1}$ luminosity).
- **Linac-ring:**
  - High current polarized electron source
  - Energy recovery technology for high energy and high current beams
- **Ion ring:**
  - Beam cooling techniques development (electron, stochastic).
  - Increasing total current (ions per bunch and number of bunches)
  - Polarized He^3 production and acceleration

Last notes

- Two design options for eRHIC are under development: ring-ring and linac-ring.
  - Zero-degree design has been produced (ZDR, 2004).
  - Present development is towards more detailed conceptual design report.

- At similar level of electron beam intensities the linac-ring design provides higher luminosity, but requires significant development for polarized electron source.

- Ring-ring design is at present level of accelerator technology, but e-p luminosity of 1.e33 $cm^{-2}s^{-1}$ is very difficult to achieve.

- On present schedule the operation would start at 2016-2017.